Waterpower on Virginius Island
(Virginius Island Hydraulic Works)
On north bank of Shenahdoah River 0.5
miles from confluence with Potomac River
Harpers Ferry
Jefferson County
West Virginia

HAER No. WV-35

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

REDUCED COPIES OF MEASURED DRAWINGS

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HISTORIC AMERICAN ENGINEERING RECORD

Virginius Island: Water Powered Industrial Village

HAER No. WV-35

Location:	In the Shenandoah River adjacent to Harpers Ferry West Virginia, approximately one half mile upstream from its confluence with the Potomac River.
Date of Construction:	ca. 1817 - 1887. Many alterations.
Present Owner:	Harpers Ferry National Historical Park, National Park Service.
Significance:	Virginius Island is historically significant because it is the site of a 19th century water powered industrial village. The study of the site offers much information on the evolution of American water power technology from water wheels through successive generations of water turbines. It also reveals characteristics of industrial villages, prototypical manufacturing communities that played a key role early American industrial development.
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INTRODUCTION

The industrial village on Virginius Island, the last island in the Shenandoah River before its waters pour into the Potomac River at Harpers Ferry, owed its birth, growth and eventual demise to one thing more than any other; the water power of the rolling river that washed along its shores. From the early nineteenth century until 1936, the Shenandoah's waters powered a succession of mills including a foundry, machine shop, cotton factories and a series of flour mills.

Much of the island's technological history lies buried beneath shifting flood deposited sands, awaiting archaeological investigation. But many documents and material remains survive. This tentative evidence shows that Virginius Island is a significant industrial archaeological site for at least two reasons. First, it contains important examples of evolving nineteenth century water power technology, and second, it was a nineteenth century water powered industrial village.

Virginius Island and the Era of the Direct Drive Water Turbine

During the island community's 120 year life span American hydraulic technology evolved through several important transitional stages. New water wheel designs highlighted each stage. Island entrepreneurs were in step with these technological improvements. They often adopted the latest water wheels and other equipment, particularly during the era between the mid-nineteeth and early twentieth centuries, the era of the direct drive water turbine.

When two cotton mills were constructed on the island ca. 1848-1850, the mill's owners installed E. C. Kilburn's version of Marcel Fourneyron's outward flow turbine. Kilburn's adaptation of the French design was one of the first water turbines employed widely in the United States. Following the Civil War, Child and McCreight converted the larger of the two cotton mills to a flour mill, installing four Leffel double turbine water wheels.[1] Leffel's turbine, perhaps the most popular of the 1870s and 1880s, was a classic example of the new "American" school of inward flow turbines.

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[1] The newspaper articles and advertisements cited in this report were first compiled in the late 1950's by Park Service Historian Charles W. Snell in A History of the Island of Virginius, (Unpublished manuscript on file, Harpers Ferry National Historical Park). The most important of these will be cited separately to direct attention to their primary source. Virginia Free Press 9 Dec. 1852: 3.

The denouement of direct drive water turbines was also played out, in microcosim, on Virginius Island. As the nineteenth century came to a close direct drive turbines, mounted directly to equipment such as pulp wood grinders, began to give way to turbines which drove electrical generators. Electric motors drove equipment more efficiently. During its waning days, the Shenandoah Pulp Mill, Virginius Island's last industry, converted a pair of its large Improved Success turbines from driving pulp mill equipment to electrical power generation.

The Industrial Village; An American Prototype

The history of Virginius Island is more than a case study in evolving turbine technology. A manufacturing community grew up around its cluster of water powered mills. Common in regions where adequate mill streams were available, many such communities flourished during that important but limited era of United States history when water power was the prime mover of the country's nascent manufacturing sector. When steam replaced water power, these stream-side industrial villages quickly began to disappear from the American landscape. In his seminal work on water power in the United States, Lewis Hunter coins the term industrial village to describe such villages. He stresses their pivotal historical role:

> these small industrial communities in important respects prepared the way for the larger industrial developments ahead; they were the next rung up in the ladder of industrial advance.[2]

Hunter draws from a variety of early descriptions and his own studies of water power in the United States to discuss industrial villages in some detail. With his work as a guide, it is possible to create a model from the regularly occurring pattern of features that distinguish this important type of early American community.[3]

The Model Industrial Village

Industrial villages were usually born from some of the earliest settlements in newly opened regions of America's expanding frontier. Such regions had two things in large supply; raw materials such as trees, and the harvest of its

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[2] Louis C. Hunter, A History of Industrial Power in the United States, 1780-1930, 2 vols. (Charlottesville: Univ of Virginia Press, 1979) 1: 178-181. For an informative study of an individual industrial village, see: Anthony F. C. Wallace, Rockdale: The Growth of an American Village in the Early Industrial Revolution, (New York: Alfred A. Knopf, 1978).

pioneer farming families. Alongside suitable streams, entrepreneurs built water powered mills to saw logs into lumber, or grind wheat into flour. Often, flour and saw mill sprang up side by side. They soon became popular gathering places. The growing concentration of potential customers lured blacksmiths, merchants and other entrepreneurs. Small communities sprang up around a growing number of mills.[3]

In these early days trade was subsistence based, conducted by barter. A farmer would bring in his wheat, have it ground, and pay for the miller's services with a share of the ground product. He might then trade another portion for the services of a blacksmith. Very little cash changed hands and most of the area's produce stayed within the community.

Often, communities that grew up around water powered mills and this pioneer system of subsistence and barter would remain little more than "crossroads villages with a miscellany of mills, workshops and stores." Occasionally, however, mill owners and merchants grown prosperous, or new entrepreneurs, lately arrived, sought to increase the profitability of their local water power. They added new manufacturing enterprises that produced commercial goods. Barter gave way to cash transactions as production for local consumption gave way to manufacturing for sale in regional or larger markets. At this point, Hunter would assert, a crossroads village became an industrial villages.

Hunter cites Middlefield, in western Massachusetts, as a case in point. There in 1815 two fulling and carding mills were added "to the usual complement of early water mills." These enterprises prospered and expanded and, by 1840, the community boasted forty workers, several tenements and a two story boarding house. The coming of the railroad in 1841 and the stimulation of demand brought on by the Civil War led to further growth. Middlefield reached an apex in the 1870's then declined because of competition from larger mills, waning popularity of woolens, fire and flooding.

An interesting feature of this scenario is an implied cycle of birth, growth, apex and decline. This is not to say that every industrial village declined, certainly some continued to grow and prosper. But those which remained committed to water power declined as it became obsolete.

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3 Hunter, 157-181.

4 Hunter, 181.

5 Hunter, 178-180.

Virginius Island and the Model Industrial Village

Virginius Island resembles Middlefield. Like Middlefield, it first enjoyed steady growth before experiencing a series of set backs. Changing technology, economics and war caused some. Flooding--the constant nemesis of hydraulic technology--caused others. Ultimately, however, the obsolescence of direct drive water turbines and the passing of water powered industry sealed the fate of Virginius Island.

Government owned and undeveloped until 1816, the island flourished after it was sold to private owners. By the 1820s, entrepreneurs had built a water powered flour mill, saw mill, oil mill and tannery. These mills spawned small hand powered shops such as a cooperage which produced barrels for flour storage and shipping.

Virginius Island grew rapidly in the 1830s and 40s. As it grew, it became less oriented to local production and more oriented to a regional market. This transition is most apparent in the island's most important industry; flour milling. Over its life span, a series of larger and more productive flour mills were built. Local newspaper advertisements chronical the growing commercial orientation of successive mills. Early advertisements emphasized community sales and barter transactions. By the coming of the large Child and McCreight mill after the Civil War, this local orientation had apparently completely disappeared.

An important step in the island's transition to industrial village was made in the late 1840s. Two cotton mills were built and textile manufacturing was begun. The new cotton mills drew even more workers to the growning community of factory workers and craftsmen.

The decade of the fifties was the island's apex. Poor timing and financial problems doomed the cotton business before it became well established. John Brown's raid and the Civil War forced other mills to close. The era of vigorous growth ended. After the war, the island reverted to less ambitious endeavors. Flour milling resumed its dominant role, followed by iron founding, saw milling and other smaller operations.

By the end of the century, the island was no longer an industrial village. Flooding had claimed several businesses. The Shenandoah Pulp Company, which built a large mill on adjacent Hall Island in the 1880s, swallowed up those that remained. In its prime, the island had boasted as many as twenty three dwellings, many of which were substantial two story brick structures. There was also a boarding house. With five waterpowered mills, other smaller businesses and a large resident work force, complete with families, it must have been a vibrant community. At the dawn of the twentieth century, all that remained were two or three tenements owned by the pulp mill. They too were abandoned after a flood in 1928.

One feature that distinguishes Virginius Island is the nature of its birth. Many industrial villages evolved, of their own accord, from pioneer settlements.[6] Virginius Island was an appendage of its parent community; Harpers Ferry, which had sprung forth less from a process of natural growth than from the urging of George Washington.

Washington had grand visions for the economic development of the Potomac Valley which included building a new "Federal City"--Washington D. C.--that would serve as "the great emporium of the United States."[7] He had marshalled the full power of the presidency to transform this dream into reality. He had also invested heavily in the region, first in land then in the Patowmack Canal Company.[8]

Harpers Ferry would play a key role in this grand scheme. As a young man, Washington had surveyed the Potomac and Shenandoah river valleys. He was awed by the grandeur of two rivers meeting to cut through the Blue Ridge mountains at Harpers Ferry. As President, he pushed for an armory to be built there, both to capitalize on the two rivers' tremendous water power and to support the region's growth.

Against some opposition, the armory was eventually built on the bank of the Potomac. In 1819, the government added John Hall's Rifle Works, built on an island in the Shenandoah immediately upstream from Virginius Island.

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[6] Another variant of the industrial village was created by John A. Lowell and a group of New England merchants known as the Boston associates. These men established a series of water powered cotton manufacturing communities before the Civil War. Unlike Virginius Island and other industrial villages that grew more spontaneously from local enterprise and capital, such communities owed their existence to outside capital and were patterned after a model conceived by Lowell and others. Lowell, Massachusetts, and other such communities have been much studied but a good summary of Lowell's model and the republican ideals-- or economic imperatives-- that lay behind it are found in John F. Kasson's, Civilizing the Machine (New York: Penguin Books, 1976) 55-106.

[7] For a discussion of Washington's motives for selecting Harpers Ferry as a site for a government armory as well as the operation Hall's rifle works, see: Merritt Roe Smith, Harpers Ferry Armory and the New Technology, (Ithaca: Cornell University Press, 1977) 27-51.

[8] Over the years, the spelling of Potomac has evolved from the original Anglicized version of an old Indian word.

Transportation projects, naturally attracted to the opening in the mountains, were further stimulated by the growth of federal enterprise. Canals came first, the Patowmack in 1792 followed by the Chesapeake and Ohio in 1833. The next year the Baltimore and Ohio reached the banks of the Potomac opposite Harpers Ferry although a railroad bridge across was not built until 1836. The Winchester and Potomac Railroad which linked Harpers Ferry with Winchester, Virginia, was completed in 1836.[9] If it was Washington's persistence that led to the growth and development of Harpers Ferry, the picture of Virginius Island in its prime coincided most closely with an image that Thomas Jefferson might have envisioned. While Jefferson had once urged that America's "workshops remain in Europe," he had grudgingly come to accept the argument that the new country would have to develop domestic manufacturing.[10] But Jefferson foresaw an alternative course of industrial development that would fit with better harmony into America's virgin frontier. Like many of his contemporaries he cherished a vision of a pastoral nation that remained close to nature. In such a society, the role of manufacturing should be subdued. Large manufacturing districts, like those which Jefferson felt had done so much to harm the quality of life in the industrial regions of Europe, were to be avoided. In their place, located among the small communities scattered throughout a pastoral country side, small manufactories would provide for local needs while offering a livelihood to widows orphans and other unfortunates.[11]

Jefferson, whose visit to Harpers Ferry occasioned the christening of an overlook above Virginius Island, could have seen the potential for such a manufacturing community on the island below. The island was small, barely twelve acres. It was only large enough for a few enterprises and a small

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9 Dave Gilbert, Where Industry Failed, Water Powered Mills at Harpers Ferry, West Virginia, (Charleston, West Virginia: Pictorial Histories Publishing Co., 1984) 35-36.

10 Thomas Jefferson, Notes on the State of Virginia (Philadelphia: R. T. Tawle, 1801) 325.

11 For a discussion of Jefferson's vision of the role that manufacturing should play in his pastoral vision of America as well as the harsh intrusion that steam power and large scale industry would occasion, see: Leo Marx, The Machine in the Garden, (New York: Oxford Univ. Press, 1968) and Kasson, Civilizing the Machine. For a specific discussion of the manner in which Jefferson had compromised his pastoral ideals to mesh with Tench Coxe and Alexander Hamilton's efforts to stimulate American manufacturing, see: Marx, 150-169.

community of workers who would benefit from the natural beauty of their surroundings.[12] It offered an excellent source of power, the water power of the Shenandoah, a harmonious feature of the environment that could drive machinery without emitting choking smoke and alarming noises like the steam engines of the day.

The Shenandoah's Water Power

The water power of the Shenandoah was the island's most attractive feature. Listed in the United States Census Bureau's 1885 report on water power as the Potomac River's most important tributary, the Shenandoah drained 2,850 square miles between Front Royal, Virginia and Harpers Ferry. The upper forty-eight miles of this fifty-four mile span passed through fertile bottom land averaging from a few hundred to several thousand feet in width. Over this distance, the drop in the river per mile averaged from seven to less than three feet. In its last 6-1/2 miles, however, between Little's Falls and Virginius Island, it dropped 12 1/2 feet per mile. In its last 2-1/2 miles from Bull's Falls, it dropped 17-1/2 feet per mile.[13] The report on water power describes the last portion of the Shenandoah from Little's falls as:

> entirely unlike the upper portions, as here the mountains are shut closely in on either bank, the bottom land disappears, and the river descends over a succession of slate ledges with more than double the average fall per mile of its whole length.[14]

The report goes on to state that while the river had experienced very destructive freshets in 1870 and 1877, flooding along the river was not, on the average, overly severe. Poor construction had made the old dam vulnerable. The river's good slate bottom would lend itself to properly constructed dams that could "withstand any freshet to which they might be subjected."[15] The last few miles of the Shenandoah offered excellent potential for water powered mills. Not the best in the country perhaps, but certainly safe enough, and adequate to the needs of any nineteenth century mill.

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12 Smith gives an excellent description of Harpers Ferry and Virginius Island as it must have appeared to Jefferson. 24-27.

13 United States Bureau of the Census, Report of the Water Power of the United States, (Washington: GPO, 1885) 46-49.

14 Report of Water Power, 565.

15 Report of Water Power, 48.

THE INDUSTRIAL VILLAGE ON VIRGINIUS ISLAND

Birth

The community of Virginius Island sprang forth suddenly. While Harpers Ferry had been settled during the eighteenth century and had grown steadily after the armory began operating, Virginius Island remained unclaimed public land until 1816. In that year, Daniel McPherson, surveyor for Jefferson County, Virginia,
acquired it by filing for a patent from the State of Virginia. McPherson sold the island the next year to John Peacher, who in turn sold it in 1823 to armory superintendent James Stubblefield. In 1824 Stubblefield subdivided the island into four tracts and sold them to local entrepreneurs.[16]

Apparently some development of the island had begun before, or soon after 1816, because title deeds of the 1824 land sales suggest that a grist mill and a mill that made oil from flax seed, along with water races, were already in place.[17]

In the period between 1824 and 1836, when the Winchester and Potomac Railroad was built through the middle of the island, a small scale building boom took place. On one of Stubblefield's four tracts, first purchased by Townsend Beckham then sold to Hugh Gilleece, the old oil mill was first expanded by the addition of a tannery and a water powered bark mill. Later, Gilleece converted the tannery to a foundry. Besides industrial structures, Gilleece also built two dwellings including a two story brick house.[18]

In what was probably true with many of the enterprises on Virginius Island, a symbiotic relationship developed between the government and these two early industries. An 1836 newspaper advertisement suggests that the armory bought at least a portion of the tannery's leather.[19] Gilleece later advertised that his foundry had cast an iron shaft weighing 3600 pounds for the armory. This trade with the government apparently had a trickle down effect. It appears that Gilleece's foundry sent rough casting work to another island enterprise, a machine shop, to be finished.[20]

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16 Snell, 11-14.

17 Snell, 13-15.

18 Snell, 18-24.

19 Virginia Free Press, 3 Mar. 1836: 3.

20 Virginia Free Press, 29 Sept. 1842: 2. Virginia Free Press, 27 July 1843: 3.

While the tannery was dismantled in the late 1830's, Gilleece's foundry became one of the more enduring industries on Virginius Island. Except for the Civil War years, when all industry on the island was halted, the foundry operated almost continuously, under a succession of owners and leasers, until it was destroyed by the flood of 1870. It offered a variety of products including threshing machines, ploughs and coal stoves. In addition to stock items manufactured from patented patterns the foundry also did custom casting work.[21]

Valued at $7,000, the water powered foundry employed eight male hands who each earned around $25 per month. It annually consumed 150 tons of pig iron and produce $12,000 worth of castings. Apparently, the size of the foundry was reduced between 1850 and 1860 because the 1860 census of manufacturing, which listed it as the Herr and Snapp Foundry, indicated a value of only $2,000. The labor force had been reduced to three, and the foundry consumed only one hundred tons of pig iron to produce ninety tons of castings valued at $7,000.[22]

Lewis Wernwag purchased another of Stubblefield's four tracts. Wernwag, a noted engineer who specialized in building wooden bridges, had come to Harpers Ferry to construct the first wooden bridge across the Potomac. He built a sawmill and machine shop, both waterpowered, on the tract that would become the site of the island's cotton mills and later its largest flour mill.[23]

Wernwag's machine shop, a three-story stone building, was well equipped. Early newspaper advertisements reveal that it was set up to turn wood, brass, iron and steel. Machinery in the shop included turning lathes, screw plates, taps and dies, bench screws and mill screws. Wernwag manufactured everything from window sash fasteners to Farham's patented washing machines. Also available was at least one of his personal inventions, a patent cutting box, which Wernwag advertised as "well adapted for cutting provender of every description for stock."[24]

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21 Snell, 47-50.

22 United States Bureau of the Census, Schedule 5: Products of Industry, Jefferson County, Virginia, 1850. United States Bureau of the Census, Schedule 5: Products of Industry, Jefferson County, Virginia, 1860.

23 D. E. Stinson, The First Railroad Bridge at Harpers Ferry, (Unpublished Manuscript of file at Harpers Ferry National Historical Park, 1970) 7.

24 Snell, 30-33, 64-64, 90; Gilbert, 31.

Wernwag's sawmill was also well equipped. While the original machinery cannot yet be documented, when the mill was renovated in 1846, two Crosbey's patent reciprocating saws and two 24-inch circular saws were installed.[25] The mill purchased all kinds of logs including pine, oak, poplar and wild cherry. It sold precut lumber but would also saw logs for customers, either for cash or in trade for every third log.[26]

Stubblefield sold another important tract of land to Fontain Beckham. It apparently contained the grist mill built some time before 1824. In 1830, Beckham advertised that a flour mill on his property, known locally as the Island Mill, was undergoing a "thorough repair."[27] Beckham also maintained a cooper's shop and four dwellings. Barrels were made in the cooper's shop to store flour and plaster, which the mill produced seasonally.[28]

The island grew steadily in the twelve year period between 1824, when it was parceled up and sold, and 1836 when the Winchester and Potomac Railroad arrived. Although its five larger industries were water powered, several hand powered industries were also established. Principal among these were blacksmith shops, and the cooperage that served the Island Mill. In addition, as many as twenty one dwellings, including at least four substantial two story brick structures, were built.[29]

While the arrival of the Winchester and Potomac Railroad did not greatly accelerate its rate, industry on Virginius Island continued to expand until John Brown's raid and the Civil War. In 1840, Hugh Gilleece added a chopping mill near his foundry that chopped rye and corn.[30] Beckham's Island Mill had burned in 1839. It was replaced the next year by a larger mill on the same site.[31] In 1857 John and George Rhor established a wagon making and black smithing business.

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25 Virginia Free Press, 3 Sept. 1846: 3; Virginia Free Press, 4 April 1851: 3; Snell, 100.

26 Virginia Free Press, 18 July 1833: 3, 2 Jan. 1834: 3, 20 Feb. 1845: 3.

27 Virginia Free Press, 28 July 1830: 3.

28 Snell, 20-24.

29 The development that took place during this early boom period is exhaustively documented in Snell, 18-80.

30 Virginia Free Press, 11 June 1840: 3.

31 Virginia Free Press, 7 Feb. 1839: 2, 14 Feb. 1839: 2.

The Rohr and Brother operation was diversified. In a series of newspaper advertisements that appeared in the late 1850s and early 1860s, the brothers announced that they carried a range of plows and farming implements and were prepared to custom-make what they did not have in stock. They also manufactured a wide range of wagons, from six horse down to light express, plus carriages, rockaways and buggies.[32] The 1860 manufacturing census listed the total capital investment in the combined wagon making and blacksmithing shop at $1800. The shop employed three hands in each of its two operations paying them around $20 per month. Wagon making annually consumed $400 worth of lumber to produce $1,400 worth of wagons and carriages, while the blacksmithing shop consumed fourteen tons of pig iron per year to produce $1,500 worth of products.[33]

Apex

In his study, Hunter observed a crucial juncture at which communities destined to become industrial villages diverged from those that would remain no more than cross roads villages. That juncture came when a community's entrepreneurs turned their attention beyond local community. "In time the profits accumulated from successful ventures by a closely knit group of local businessmen were invested in new fields."[34] For Virginius Island that juncture arrived at mid-century. In the late 1840s, several island entrepreneurs joined with associates from Harpers Ferry and formed the Harpers Ferry and Shenandoah Manufacturing Company. The new company was to be strictly commercial, directed toward manufacturing and sales in a regional if not larger market. Virginius Island had reached its apex as an industrial village, an apex that was shortlived.

In an association that was stormy at best, marked by varying levels of solvency among its members, the Harpers Ferry and Shenandoah Manufacturing Company constructed two factory buildings. One was originally planned as a cotton mill the other as a paper mill. Indicative of the indecision that was to contribute to its bankruptcy a few years later, the company abandoned plans

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32 Snell, 119.

33 Products of Industry, 1860.

34 Hunter, 180.

for the paper mill during mid-construction. Instead it built two separate cotton mills, an untimely decision when consolidation of larger and larger operations under one roof was the norm. The company was finally forced to lease the smaller mill and concentrate its energies on the larger mill.[35]

Despite their management problems, the company constructed two very fine mills. The larger mill, a four story brick building, consisted of separate carding, spinning, dressing and weaving departments. Its cotton machinery was built by Charles Danforth of Patterson, New Jersey. It included eighteen spinning frames each with 132 spindles for a total of 2,376. The mill produced four by four sheeting.[36]

Comparative census data for 1850 reveals that even the larger mill was small. While the average cotton mill in the United States used 586 bales of cotton per year, the mill on Virginius Island used only 473. The mill also employed fewer workers. The average American mill employed eighty-four workers--fifty-four female and thirty male--compared with the Virginius Island mill which employed thirty-five male and thirty-five female workers.[37]

The second mill was even smaller. While the first mill was 104 feet by 48 feet, the second four story structure was only 57 feet by 48. It contained machinery similar to that in the first mill, including four Danforth Cap Frame spinning frames.[38]

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35 The particulars of the company's financial problems are outlined in Snell, 81-104. A lively debate over the prospects of the mid-19th century U.S. cotton industry, which was carried on primarily in the Nov. 1849 - Jan. 1850 editions of Hunt's Merchants Magazine, provides some insight into the problems that the industry was facing. See also, Charles T. James, Letters on the Culture and Manufacture of Cotton, (New York: George W. Wood, 1850): 1-25.

36 An advertisement that appeared in the Virginia Free Press on April, 8 1852: 3, indicated that the mill was for sale by court order. In addition to the 18 frames the advertisement listed the following machinery; 1 patent Cotton Opener and Cleaner, 2 Pickers for double operation, 18 thirty-six inch Carding Engines with railway and heads attached, 3 patent Drawing Frames, 6 Double Roller Beam Speeders, 4 dressing frames with Copper Steam Heaters, 6 Cradle Warpers and 97 looms.

37 Products of Industry, 1850, United States Bureau of the Census, J. D. B. De Bow, Compendium of the Seventh Census, (Washington: Beverly Tucker, Senate Printer, 1854) 180; Melvin Thomas Copeland, The Cotton Manufacturing Industry of the United States (1912: New York: Augustus M. Kelly, 1966): 7-9.

38 Other equipment in the mill included seven carders, two reels and a Warning mill. Virginia Free Press, 2 Aug. 1849: 2.

The smaller mill employed only fourteen workers, six male and eight female who produced batting, yarn warp and candle wick.[39]

The arrival of cotton manufacturing, as short tenured as it would be, pushed the island's population to its peak. The 1830 census had recorded a population eighty-nine people. By 1840, the population had increased to 113 people. The 1850 census revealed that the island's population had grown to 186 persons. To house its new workers the cotton mill owners maintained four large two story stone dwelling houses, five two story brick tenements and five one and a half story wooden cottages.[40]

These same population figures also reveal that, as it grew into an industrial village, Virginius Island diverged from the social and economic course of Virginia, and the South. While the south became more intellectually and economically committed to slavery, the entrepreneurs on the island abandoned the institution. In 1830, the community included nineteen blacks: one free female and eighteen slaves. By 1840, the number of slaves had dropped to two while the number of free blacks had increased to three. Add these free blacks to the growing number of European immigrants, such as the English textile workers from Manchester, who were drawn to the new cotton mills, and clearly by 1850, Virginius Island was more a northern than a southern community.

The Cotton Mills' Fall River Turbines

The new cotton mill's new prime movers were the latest innovation in American water power technology; two 5' 10" Fourneyron turbines designed by E. C. Kilburn of Fall River, Massachusetts.[41] The Kilburn adaptation of Marcel Fourneyron's original design was one of three introduced in the United States in the 1840's. American inventors had experimented with crude turbines designs and some had been patented, but the Fourneyron turbine was the first to be widely copied in the United States.[42]

While the Fourneyron turbine grew out of a European school of design, it was based on the same basic principle as its successors on the island which

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39 Products of Industry, 1850.

40 Snell, 17, 41, 99.

41 Virginia Free Press, 9 Dec. 1852: 2.

42 Jonothan Thayer Lincoln, "Material for a History of American Textile Machinery," Journal of Economic and Business History 4 (1932): 269-273; Arthur T. Safford and Edward Pierce Hamilton, "The American Mixed Flow Turbine and Its Settings," Transactions of the American Society of Civil Engineers, 85 (1922): 1242.

belonged to the generic category of "American" turbines. Both Fourneyron and American turbines were reaction water wheels. They were based upon the principle that for every action there is an equal and opposite reaction. Reaction wheels channeled water through an enclosed chamber filled with vanes which deflected its path of movement before it was allowed to escape. The action of the water on the vanes, referred to as floats, forced the vanes backward in the opposite direction from the flow of water. The vanes were attached in a variety of ways, thus accounting for the multitude of turbine designs, to a shaft which was turned as the vanes rotated. The shaft was either attached directly to a grinding wheel or other device or was attached to gearing.[43]

The reaction wheel had been in use for centuries before the principle upon which it was based was formerly written into physics books. Known as a tub wheel, it had been used in grist mills since ancient times to supply a low but reliable source of power.[44]

The tub wheel was laid on its side, or horizontally, a feature which distinguished it from another ancient category of wheels; the gravity wheel. Gravity wheels, the type most commonly depicted in pastoral paintings of early mills, were mounted vertically with a horizontal shafts. Classified as undershot, overshot or breast wheels, according to where on their circumference they were first struck by water, they were turned as the weight of the water, accumulating in buckets, was pulled downward by gravity.[45]

The greatest advantage of the tub wheel was its horizontal spin which meant that its shaft could be mounted directly to grinding wheels which rotated horizontally. Another advantage of the horizontal tub wheel was that it did not require a large fall of water. This feature doomed the gravity wheel to earlier obsolescence as the power demands of the industrial revolution mounted. To increase the power of a gravity wheel, it was necessary to increase its circumference and water volume. The power of the tub wheel, on the other hand, could be significantly increased by only minor increases in circumference. Plus, its action was not hindered by back water. Gravity

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43 Daniel W. Mead, Water Power Engineering (New York: McGraw Publishing Co., 1908): 236-245; Robert E. Horton, "The Turbine Water Wheel as a Prime Mover," Clarkson Bulletin, 7 (1910): 11-15; Joseph P. Frizel, Water Power, (New York: John Wiley and Sons, 1900): 255-259, 261-265.

44 John Reynolds, Windmills and Watermills, (New York: Praeger Publishers, 1970): 12.

45 Gilbert, 20-23.

wheels could not operate when high water backed up in the tail race and partially submerged the bottom of the wheel. Because of these advantages, 19th century inventors began with the reaction tub wheel as they worked to develop modern, high power turbines.[46]

Similar as American and European turbines were in basic principle, their patterns of water flow differed significantly. In European turbines, water entered from the top, was deflected around vanes and allowed to escape out the side of the housing encasing the wheel. Turbines whose water discharged from the side were called outward flow wheels. In American reaction wheels, water usually entered the housing from the side, was deflected around vanes and then escaped from the bottom. They were called inward flow wheels.[47]

Marcel Fourneyron drew upon the ideas of earlier French inventors, to become Europe's leading turbine designer in the 1830s. His outward flow reaction wheel, generally considered to be the first true modern turbine, was widely publicized. American innovators led by Ellwood Morris adapted the design to American uses. While Morris was the first to place a Fourneyron turbine in the Rockwell Cotton Mill on the Brandywine River near Philadelphia in January, 1843, he was soon surpassed by two inventors who entered the business on a larger scale.[48]

One of these inventors was Uriah A. Boyden of Lowell. The other was George Kilburn of Fall River, Massachusetts. Boyden became the more widely known of the two after installing a Fourneyron-like turbine at the Appleton Cotton Mills at Lowell in 1845. But the two men were acquainted and, in a practice that was common in the era, had shared ideas on turbine construction. Boyden had even visited the print works of Andrew Robeson and Sons in Fall River, where Kilburn and his brothers John and Elijah were developing their version of the Fourneyron turbine which was installed in 1844.[49]

By 1846, E. C. Kilburn and Company was selling turbines. They were soon in demand from New England all the way to the deep south. The company custom designed larger turbines but kept a range of smaller turbine in stock for

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46 William Cullen, A Practical Treatise on the Construction of the Turbine or Horizontal Water Wheel (London: E. and F. N. Spon, etc., 1860): 12-13.

47 Mead, 243-245; Safford and Hamilton,1242, 1249, 1261.

48 Hunter, 318-326; Lincoln, 268-269.

49 Lincoln, 268.

immediate delivery. These smaller turbines became a mainstay of the cotton milling industry. By 1857 the company stocked patterns of wheels in ten sizes ranging from 21 to 108 inches in diameter.[50]

The 72 inch Kilburn-Fourneyron turbines, which came to be known simply as Fall River turbines, were about mid-size in the company's line of stock wheels. Under 14 foot of fall they probably delivered around 60 or 70 horsepower. Their combined total of around 140 horsepower dwarfed in comparison with 2,872 horsepower that the Shenandoah Pulp Mill's ten turbines would later deliver.[51]
But at this nascent stage in American turbine technology, they were a leader in the field. For the first of three times in Virginius Island's history, its entrepreneurs had adopted the latest innovations in water turbines.

Virginius Island During the Civil War

While many industrial villages safely removed from the front lines profited from the Civil War, Virginius Island suffered. It was too close to the fighting. Harpers Ferry changed hands eleven times during the war making it virtually impossible for the island's mills to operate.[52] Abrahm Herr, who had gained ownership of the entire island from the Harpers Ferry and Shenandoah Manufacturing Company bore the brunt of the loses. While it has not been documented, there is a strong possibility that his buildings were looted by Confederate troops when they removed the machinery and equipment from the Armory and Hall's rifle works on the island upstream from Virginius.[53]

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50 Lincoln, 272-273.

51 Lincoln, 272; W. E. Truesdell, Report submitted to Jefferson Power Co., Shenandoah Pulp Co., etc., 16 Sept. 1919, Savery Collection, Hagley Library, Wilmington, Delaware.

52 Smith, 322.

53 After the Civil War Abrahm Herr filed a claim with the government for rent due him claiming that federal troops had occupied Virginius Island between 1862 and 1866. One of the documents included in the packet of information regarding that claim, on file in the National Archives, indicates that all the equipment in the cotton mill had been removed prior to 1862, United States Senate, 55th Congress, 1897, 1st Session, Document number 33.

Herr was a union sympathizer. At one point he was arrested by the Confederates and charged with war crimes. The charges are not known but on at least one occasion he collaborated with Union troops who had confiscated all the wheat and flour from the flour mill. The Yankees ferried it across the Shenandoah under cover of darkness. Herr was rewarded the following night by a Confederate raiding party, disguised in civilian clothing, that burned the mill to the ground.[54]

The entire island was commandeered by Union troops. Various buildings were used as offices, troop billeting and stables. After the war Herr attempted to claim rent and compensation for damages charging that the Union occupation lasted from 1862 through 1866. The claim, which was finally resolved in 1909, long after Herr's death, was only partly compensatory. The government ruled that Herr's estate was not entitled to the full claim because all of the machinery and equipment from the island's industries had been removed some time prior to the arrival of Federal troops.[55]

Retreat to an Old Mainstay

At war's end, the task of bringing the island's mills back into operation required not only repairing war damages but also re-equipping the various industries. Faced with such an expensive task, Herr sold out. Virginius Island's new owners, Jonathan C. Child and John A. McCreight, chose to fall back on what had always been the island mainstay: flour milling, rather than resume the risky business of cotton manufacturing. In the building in which the cotton mill had been located, they installed a modern merchant flour mill complete with four new Leffel turbines.[56] Herr's old mill, its insides gutted by the wartime fire, was abandoned and left standing.

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54 Joseph Barry, The Strange Story of Harpers Ferry (Shepardstown, W.V.: Shepardstown Register, 1979): 114; Report of Col. John W. Geary, 18 Oct. 1861, Official Record of the War of the Rebellion (Washington: GPO, 1881): Series 1, Volume 5, 239-243.

55 Senate Document, 55.

56 Snell, 129. While little documentation exists of the Child and McCreight flour mill, the Leffel turbines are still standing in the ruins of the mill.

The Leffel Turbine

The Leffel turbine led the reemergence of native American inward flow turbines. Samuel B. Howd of Geneva, New York, had patented an early version of the inward flow wheel in 1838, but it was soon forgotten as word of Marcel Fourneyron's success spread. Outward flow turbines preoccupied Americans for the following decade. In 1853, however, James B. Francis, chief engineer and superintendent of the Lowell hydraulic works, convinced his employers to purchase the Howd patent. Frances began installing improved inward flow turbines, based upon Howd's design, in local mills. His success inspired other American inventors. In 1859, the Stout, Mills and Temple Company patented the original American inward flow turbine. An adaptation of Francis' design, it was modified to give an inward and downward discharge.[57]

According to Hunter, Stout, Mills and Temple were founders of the what he terms the stock-pattern industry, which manufactured turbines on a large scale and maintained stocks of patterns and pre-made wheels. The same claim might be made for Leffel and his Fall River turbine.[58] Mills and Temple were located in Dayton, Ohio, the same town where Stillwell and Bierce were developing a rival inward flow turbine. Meanwhile, James Leffel, was perfecting his mixed flow turbine in nearby Springfield, Ohio. All three companies must have influenced each other, both in turbine design and marketing techniques.[59]

Soon Leffel dominated the field. He developed a new type of inward flow turbine that had two sets of vanes. These double vanes deflected the water two ways before it was discharged. Leffel called his innovation a mixed flow turbine. While it was not significantly more efficient than competing turbines, it was well built and durable. It became one of the most widely used turbines in the United States for the next few decades, a standard of the stock-pattern trade.[60]

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57 Safford and Hamilton, 1242, 1253-1255.

58 Safford and Hamilton, 1261; Hunter, 385-388.

59 Hunter, 356.

60 Hunter, 374.

The term "American" rapidly became generic, applying to all U.S. turbines patterned after the Houd-Francis design. It was an apt term for more than one reason. Not only was this new generation of wheels purely American in design, they were produced in factories that employed the "American System" of manufacturing.[61]

Once again, Virginius Island's entrepreneurs were in step with a significant transition in the history of American water power technology. Child and McCreight's four new Leffel mixed flow turbines were not much more powerful than the Fall River wheels they replaced. They produced seventy-five horsepower each, for a total of three hundred horsepower. But they were ready made, cheap and could be ordered from a catalog. And they were a leading example of native American turbine design, reemerging after temporarily eclipsed by Fourneyron's outward flow wheel.[62]

Flour Milling on Virginius Island

It is not surprising that Child and McCreight would return to flour milling. Wheat had long been the principal crop of local farms. As late as 1850, Virginia was the nation's fourth largest wheat producer. The wheat farms of the Potomac and Shenandoah valleys were a major factor in Virginia's wheat production. In 1850, Jefferson County, in which Harpers Ferry was located, ranked third in state wheat production, with an annual product of 472,000 bushels. Adjacent Loudon county ranked second with 563,000 bushels. Combined, the two counties grew almost 10% of Virginia's wheat.[63]

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61 It is an interesting coincidence that such an important product of the "American System" of manufacturing would figure so prominently in the history of Virginius Island. Just upstream, John Hall's Rifle Works had pioneered many of the techniques of the new system which was to figure so prominently in the American Industrial Revolution. For two discussions of the "American System," see: Harpers Ferry and the New Technology, and David A. Hounshell, From the American System to Mass Production, 1800-1932: The Development of Manufacturing Technology in the United States (Baltimore, Maryland: Johns Hopkins University Press, 1984).

62 James Leffel and Company published regular catalogs that provided charts listing the horsepower of the various sizes of Leffel turbine. See: Illustrated Descriptive Pamphlet and Price List of Leffel's American Double Turbine Water Wheel (Springfield, Ohio: Republic Printing Company, 1969): 43-45. 21

63 J. D. B. De Bow, The Seventh Census of the United States, 1850 (Washington: Robert Armstrong, Public Printer, 1853): lxxxiii, 275-276.

The fortunes of geography made Virginius Island a natural collection point for this bountiful harvest. Since the cost of transporting flour was lower than for unprocessed grain, it was cheaper to grind the wheat before shipment. First canals, then the railroad, could deliver all the flour the island could produce to Baltimore, a national market center for flour, at very convenient rates.[64] Every fall wheat from the Shenandoah and Potomac valleys poured onto Virginius Island to be ground into flour, packed into newly made barrels and shipped east.

Data from the 1850 and 1860 census helps place the scale of flour manufacturing on Virginius Island in a national, regional and local perspective. In 1860, the annual value of flour produced by the average mill in the United States was $17,924. Herr's mill was much larger, producing $233,400 worth of flour annually. It dwarfed surrounding mills. In 1850 it ground 15,000 bushels more wheat than the largest mill in nearby Washington County, Maryland. The disparity was even greater a decade later. The average annual value of flour produced in Jefferson county in 1860 was $13,102, nearly eighteen times less than Virginius Island's mill. In the state as a whole, where average annual value was $11,461, the gap was even greater.[65]

Of all its industries, flour milling best exemplifies the process that transformed Virginius island into an industrial village. While other island industries enjoyed long tenures, including iron founding and saw milling which continued for around thirty-five years, and pulp wood making, which would continue for over fifty years, flour milling thrived for over sixty years. Since it endured so long, it exhibits the greatest amount of change over time. A transformation, from community focused mills serving a premarket subsistence economy to commercial operations serving a regional market, is apparent from the first mill, built some time after 1817, until the inauguration of Child and McCreight's operation following the Civil War.

Little is known about the first mill. Fontain Beckham's deed refers to it as a grist mill rather than a flour mill suggesting a community rather than commercial orientation. Grist mills ground the whole grain of wheat with little effort at cleaning. This coarse dark flour contained ground wheat germ and much of the outer coating of the grain. While acceptable to local farmers and their families, it could not compete commercially with the cleaner, whiter product of large merchant mills. In addition, grist mill flour contained more

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64 John Stork and Walter Dorin Teague, Flour for Man's Bread (Minneapolis: Univ. of Minnesota Press, 1952): 149-151.

65 Census of 1850, 275-276, Manufactures of the United States (Washington: GPO, 1865): 604, 618, 636, 638, 736, Products of Industry, 1850, 1860.

oil and moisture making it more likely to spoil in transit to an urban market.[66]

In 1830, Beckham advertised that his mill was undergoing a thorough repair. Whether Beckham is referring to a mill that he built after purchasing his island tract in 1824, or whether he is referring to renovation to the original grist mill is not certain. The newly repaired mill however, was now a dual operation that conducted both community and commercial work:

> The undersigned informs the farmers of Jefferson and Loudon, that ... he will continue the business, as usual ....The usual quantity of flour will be given for merchantable Wheat, and the inspection warranted in Baltimore or the Cities of the District. In cases where customers prefer it, the barrels will be given instead of the offal. Country work done at the shortest notice; and the highest market price in cash given for wheat delivered in the mill.[67]

This very informative newspaper advertisement reveals a growing commercial orientation in the early 1830s. The mill still did some work for the community. It still traded flour for wheat, or it would do country work, that is, grind a farmers wheat in exchange for a share. But it would also pay cash for wheat which it would then grind and ship to either Baltimore or the District of Columbia.

Beckham's mill, which was known locally as the Island Mill, was substantial. It was sixty feet long and forty feet wide. Two water wheels drove two pair of burrs-- with room for another-- and a pair of country stones. It changed ownership over the years until it was destroyed by fire in February 1839. The large size of the mill is suggested by the fact that 12,000 bushels of wheat and 300 barrels of wheat were destroyed by the fire. At the time of its destruction, the mill was valued at $20,000.[68]

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66 While Stork and Teague provide a detailed discussion of the history of flour milling an excellent short summary can be found in, Susan Winter Frye, "Evolution of Mill Settlement Patterns in the Antietam Drainage, Washington, County Maryland," thesis, The College of William and Mary in Virginia, 1984, 19-36. Frye's work offers the additional advantage of being specifically directed at the milling industry in the region around Harpers Ferry.

67 Virginia Free Press, 29 Sept. 1831, p. 3, c.6.

68 Virginia Free Press, 7 Feb. 1839: 2, 14 Feb. 1839: 2.

Flour milling had become so lucrative that a new three and a half story mill was immediately built upon the site of the burned mill. The new mill changed owners and managers over the years until it was acquired by Abrahm Herr. Herr continued to make improvements on his mill which eventually came to be known as Herr's Mill. In 1850 he reported to the census taker that it was worth $90,000, substantially more than the old Island Mill. By 1860, its value had doubled.[69]

Child and McCreight's flour mill was even larger. It ground 400,000 bushels of wheat annually, producing 80,000 barrels of flour worth $700,000. Its four Leffel turbines powered ten grinding stones. It employed thirty workers.[70]

Virginius Island and Washington County's Crossroads Villages

Virginius Island's transformation is more apparent when contrasted to neighboring communities that never became more than crossroads villages. Susan Winter Frye's study of nearby Washington County, Maryland, provides a vivid picture of the normal life cycle of small flour milling communities in the region. Frye identifies two prominent trends that occurred in the nineteenth century after a late eighteenth century era of vigorous growth. On the one hand, the rate of commercialization began to slow. County mills became less market oriented and more community oriented. On the other hand, there was a trend away from an earlier tendency to combine more than three waterpowered industries at a single location.[71]

According to Lewis Hunter, this leveling off, or slowing down, doomed a community to remain no more than a crossroads village.[72] In Washington County's early days flour mills had attracted other waterpowered industries. Herein were the seeds of industrial villages. But the transportation revolution passed Washington County by, and the favorable convergence of circumstance, that might have nourished that seed, never appeared.

Virginius Island, located at Harpers Ferry where canals and railroads met to pass through the natural opening in the Blue Ridge Mountains, grew into an industrial village.

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69 Products of Industry, 1860.

70 United States Bureau of the Census, Schedule 4: Products of Industry, Jefferson County, West Virginia, 1870

71 Frye, 57, 71.

72 Hunter, 178.

Decline

For a few years following the Civil War, Child and McCreight continued to operate or lease the foundry, machine shop, carriage shop and saw mill. But the island's total numbers of workers was less than it had been when the two cotton mills were in operation, and cotton milling would never return to the island.

The flood of 1870 dealt a devastating blow. It destroyed the foundry, machine shop, wagon shop and saw mill. It also did considerable damage to the headgates that controlled water flow into the flour mill turbines. While the headgates were rebuilt and the flour mill put back in operation, the other mills apparently were not rebuilt.[73] The era of Virginius Island as industrial village had passed.

The lure of water power had declined. Beginning around the close of the Civil War, water power gradually lost its dominance as the nation's primary source of industrial power. The census of 1900 clearly revealed this decline. It reported that, while in 1870 water power had provided 48.2% of the industrial horsepower in the United States, in 1880 it had provided 35.9%. In 1890 it had provided 21.2%. By 1900 it provided only 15.3%. Steam power, on the other hand, had risen into prominence at about the same rate that water power was declining. While, in 1870, steam and water power provided roughly equal percentages of industrial power, in 1900 steam provided 77% of the nation's horsepower to water power's 15%. The remaining 8% was provided by a rapidly rising new source, itself generated by steam or water power; electricity.[74]

The decline of water power was linked to the changing nature of American industry. As a result of the country's expanding railroad transportation system and the growth of large urban areas, industry moved to the cities. Not always near adequate water power, this new urban-based industry turned to steam power. Lewis Hunter called this new city-centered industry an industrial economy. He contrasts this dynamic new economy to the old economy of rural-based, water powered industry. The latter half of the nineteenth century was an era of transition from the old to the new economy:

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73 Emily E. Child, letter to Mrs. Sallie B. Child and Miss Lucy Child, 7 Oct. 1870, Savery Papers, Harpers Ferry National Historical Park, Harpers Ferry, West Virginia.

74 United States Bureau of the Census, Manufactures: Part 1, United States by Industries, Twelfth Census of the United States, 1900, Washington: United States Census Office, 1902: cccxxi, cccxxv.

> during the years of transition the two kinds of motive power (steam and water) seemed almost to become identified with different industrial economies, the one associated with the older industrial regions and the mill industries and industrial villages of the past and the other with emerging dynamic and diversified economy of the future.[75]

Flooding had not caused the demise of the industrial village on Virginius Island. American industrial history had reached the end of an era. Water powered manufacturing, and the rural based industrial villages that had been its foundation, had become obsolete. A prototypical American community, in many ways unique because of its frontier origins and resulting pattern of development, had become so tied to a form of technology that the two passed from the landscape together.

Reprieve

Though its prime had passed, Virginius Island was still an attractive industrial site. Water powered manufacturing, though no longer practical for most industry, could still be profitable for those with special needs. When the Federal Government sold adjacent Hall Island and its water power privileges, in the late 1880s, an expanded length of the Shenandoah was available for development.[76] With proper head gates, dam and water impoundment a fall of 24 feet was possible, a significant improvement over the 12 to 14 foot of fall that had been previously available.

To the right type of industry, a second attraction also remained. Virginius Island could still serve as a collection and distribution point. Local raw materials that were expensive to ship in unprocessed bulk form could be gathered at the island, partially or completely processed to a lighter more valuable commodity and shipped more economically to outside markets. The natural advantage that had served so long and well for wheat could also be turned to the spruce wood that grew profusely along the water sheds of the Shenandoah and Potomac. Gathered at Virginius Island and converted into wood pulp, it could be shipped economically and sold to paper mills at a profit.

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75 Hunter, 495.

76 Gilbert, 69.

77 Manufactures, cli.

A NEW ERA: PULP WOOD MANUFACTURING

While its industrial village had died along with the industrial economy of water power, Virginius Island found new life with wood pulp making. According to the twelfth census of the United States, conducted in 1900, the print and paper industry had become one of the six great industries of the United States.[77] Wood pulp manufacturing was a key sector of this rapidly rising great industry. Since the invention, in the 1850s, of mechanical processes for grinding previously uneconomical but plentiful spruce trees into pulp, cheap news print had become available. The newspaper industry had taken off, further stimulating the growth of wood pulp manufacture. From 1890 to 1900, capital investment in the paper and pulp industry increased 87%, from 90 to 170 million dollars.[78]

An enormous appetite for water kept wood pulp making tied to water power. In mechanical processing, rapidly spinning stones ground lengths of spruce into pulp. The large grinding stones were driven by shafts connected directly to water turbines. A steady flow of water was maintained inside the grinders to creat a slurry of wood pulp. Excess water carried off waste materials.[79] Since water played dual roles, as both power source and processing agent it was natural that the same sites that lured the water powered mills of the old industrial economy would now lure mills of the growing wood pulp industry.

Thomas H. Savery

Thomas H. Savery, an inventor and executive with the Pusey and Jones Company of Wilmington, Delaware, purchased Hall's Island from the government on October 22, 1884.[80] Savery knew the wood pulp industry well. While he had begun his career in the steam engine shop of Pusey and Jones, Savery soon turned his attention to the machinery and equipment used in the paper industry. He began associating with paper mill owners along the Brandywine River between Wilmington and Coatsville, Delaware. When the Jessup and Moore Paper Company offered a cash reward for a practical system for quickly adjusting mill

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78 Victor S. Clark, History of Manufactures in the United States, Vol. II, 1860-1893, (New York: Peter Smith, 1949): 485-487; Manufactures, 1015.

79 Hunter 519, "Machinery for the Preparation and Treatment of Mechanical and Chemical Wood Pulp," The Pusey and Jones Company, (1908): Bulletin No.4, 1-2; Manufactures, 1900: cccxxi, 1026.

80 Gilbert, 69.

pulleys, Savery invented an "expanding pulley" that could be adjusted while still running. He followed this early success with other patented devices employed in the pulp and paper industry. He also purchased and patented the inventions of others. Savery eventually came to control the patent rights to machines such the shake, which shook excess water from pulp slurry, and a pulp saver which recovered a significant amount of the pulp that was normally lost in the grinding process. Other patents covered important components such as wood grinder washer bushings, drum winders and felt tighteners used on a variety of machines and equipment sold by the Pusey and Jones Company. As late as 1910, the company, a leading manufacturer of machinery for paper mills, paid regular royalties to Savery for twelve separate patents.[81] With his intimate knowledge of the technology of wood pulp manufacture and his association with Pusey and Jones, Savery could build the most modern of pulp mills on Virginius Island.

Pulp Mill Construction

Construction of the new mill, known locally as the Savery mill and formally as the Shenandoah Pulp Company, was begun in April 1887. It consisted of two separate projects. The first project was the impoundment system; the dam, headgates, and lake that were to provide a reservoir of water to power the mill's turbines. The second project was the mill building.

The Impoundment Lake

The impoundment was built to take advantage of the old system that had served the government rifle works. The dam which channeled water into the impoundment was 3' 10" higher than its predecessor. It was constructed of log cribs filled with stone and reinforced on the upstream face by stone backing packed in by hand. Located a mile upstream from the pulp mill, it extended all the way across the river. The dam channeled water through ten headgates into a canal which widened to form the impoundment lake. The headgates were 14 feet high with individual arched gates that were 6' high and 5' wide. When fully opened, the gates could divert the entire flow of the Shenandoah River into

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81 Savery's patents included welded steel digesters used in making chemical wood pulp. As royalty he received one-half of the net profit earned on all digesters installed by Pusey and Jones. In addition, Savery's patents included the Old Style and New Century wood pulp shakers. "List of Patents upon the Pusey and Jones Company Have been paying Royalties Noted To Thomas H. Savery," July 15, 1910, Thomas H. Savery Papers, Hagley Library, Wilmington, Delaware.

the canal, which was used not only for power but also to soak logs before they were taken into the mill to be ground into pulp.[82]

The new Lake Quigley impoundment, named after the company's executive director John F. Quigley, was controversial. It not only blocked the flow of water to Child and McCreight's mill, but also caused water to back up into the tailrace of the old Strider mill located just upstream of the dam and headgates. The owners of the two mills brought separate cases against the Shenandoah Pulp Company.[83] Apparently, both cases failed because construction continued and the mill was soon placed in operation.

The Pulp Mill Building and Equipment

In the first stage of mill construction, five stone flumes were built. They served a dual function: first as the foundation of the upstream portion of the mill, second, as the housing for the ten water turbines that powered the mill's wood grinders and other machines.[84]

The flumes were large tanks which held water from the head race. The turbines installed inside were totally submerged. Water from the flume passed through the turbines and out the tail race at the lower end of the mill. As it passed through the turbine, the water rotated large wheels connected to shafts. The shafts were either directly connected to wood grinders or to gearing and belts which powered the mill's other machinery.[85]

The mill's room arrangement accommodated its turbines. The wood grinder room was located on the lowest floor at the downstream end of the mill. Since each of the mill's four three pocket Pusey and Jones wood grinders were driven by a

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82 Joseph Wallace and Co., Industrial Engineers, report, 16 Sept. 1919, T. H. Savery Papers, Hagley Library, Miller v Shenandoah Pulp Co., Supreme Court of Appeals of West Virginia, Sept. Term, 1883, Charles Town.

83 Gilbert, 69-70; Miller v. Shenandoah Pulp Company.

84 Descriptions of the mill are contained in 1908 and 1919 reports compiled for the Shenandoah Pulp Company by engineering firms, F. W. Ballard, report to Thomas H. Savery, 3 June, 1908, Savery Collection, Hagley Museum, Wilmington, Delaware, Joseph H. Wallace, report.

85 Joseph P. Frizell gives an informative description and account of the function of flumes in, Water Power (New York: John Willey and Sons, 1900): 311.

horizontal shaft directly connected to a pair of turbines, they were located on the same floor as the turbines, separated only by curved metal retaining plates. The retaining plates served as one wall of each flume. They prevented water from bursting through and flooding the grinder room. The turbine drive shaft protruded through the retaining plate alongside a separate shaft. Mounted to gears, this second shaft was rotated by a hand wheel to regulate water flow through the turbines. The rate of water flow determined the rotating speed of the grinding stones.

The grinding stone contained in the standard three pocket Pusey and Jones wood grinder was 54 inches in diameter and 27 inches wide. It was enclosed in a metal chamber that was mounted with three compartments, or pockets, into which 24 inch sections of clean freshly debarked lengths of wood were inserted by hand. Hydraulic presses in the top of each pocket forced the wood against the stone at a steady rate.[86]

A large volume of water ran through the grinders as they rotated. Mixing with the freshly ground pulp it created a slurry, called stuff, which was pumped to the upper level of the mill to be shaped into sheets.[87]

The upper level was located directly over the grinding room and extended upstream over the turbines. One pair of turbines, capable of producing 106 horsepower, were mounted with a vertical shaft which extended into this upper story. The shaft was connected by gears to a shaft and pulley arrangement that drove the machines and equipment which prepared wood to be sent to the grinders and processed the stuff as it was received from the grinding room.[88]

In the upper plant logs, which had been shipped by rail and deposited in lake Quigley, were stripped of their bark, sawed into lengths and fed by chutes to the wood grinders below. Two Holyoke Machine Company disk barkers handled the debarking chores, while a cutting off saw of undetermined manufacturer cut the logs into the proper lengths.[89]

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86 Pusey and Jones, 3. The process created so much friction, wearing stones down at such a rate, that many mechanical pulp mill sites can readily be identified by the large number of old worn stones scattered about. While only one such worn grinding wheel is readily visible at the Shenandoah Pulp Mill site, across the ridge at the Harpers Ferry Paper Company mill site, numerous old grinding wheels are to be seen.

87 Manufactures, 1026, Joseph Wallace report, 3.

88 F. W. Ballard, report, Joseph H. Wallace, report, 2-3.

89 Joseph Wallace report, 2.

Besides machinery that prepared wood for grinding, the upper story of the mill also contained screens which removed excess water from the wood pulp and wet machines which pressed it into sheets. Both were manufactured by Pusey and Jones. The slurry was pumped, via centrifugal pumps, onto one of five Gould patent screens. The screens vibrated as a layer of pulp from 1 1/2 to 2 1/2 inches passed across and onto 62 inch wide one cylinder wet machines. The screens were turned by rollers, which moved the pulp until it is picked up by couch rollers on the wet machine.

The couch rollers finished the job of water removal. They were covered with endless woolen felts, which guided the pulp between press rolls which bonded the stuff into sheets. Called leaf, sheets were from 40 to 45% dry. Pulp leaf could be shipped cheaper than logs. It was still heavy with moisture, however, and pulp manufacturers preferred to limit shipping distances as much as possible.[90]

The mill produced around 20 tons of pulp a day. This was an average figure that dropped considerably during the summer months, when dry weather reduced the water supply by as much as 25%.

The Pulp Mill Turbines

Savery installed the latest and best turbines in his new mill; six Improved New American turbines with horizontal shafts, two Improved Success turbines with horizontal shafts and two Improved Success turbines with vertical shafts.[91]

The new turbines' combined total of 2,234 horsepower dwarfed earlier island mills. The enormous appetite of its wood grinders, each requiring more power than all remaining equipment combined, demanded most of the mill's capacity. In 1919, after the plant had been operating for over thirty years, each aging pair of horizontal turbines could still deliver 532 horsepower to their respective grinders.[92]

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90 Manufactures, 1026, "Wet Machines and Cylinder Paper-Machines," The Pusey and Jones Company, (1908): Bulletin No. 2, 1-6.

91 Gilbert, 71.

92 Pusey and Jones, 3; Joseph Wallace report, 2.

All were inward flow turbines. The New American wheel was the newest version of the first American turbine patented by Stout, Mills and Temple in 1859. The Dayton Globe Iron Works of Dayton, Ohio, had taken over the construction of the wheel advancing it through various stages and increasing its capacity significantly.[93] This improved turbine turned on a vertical axis allowing its drive shaft to be positioned horizontally. For mechanical pulp machines whose grinding wheels turned on a vertical axis, this was an ideal arrangement. The horizontal turbine shaft could be directly mounted to a mechanical grinder.[94]

The Improved New American could be mounted in tandem, inside a common housing, so that two wheels could drive one shaft. This innovation had originally presented some difficulties because the wheels were mounted so that their bottoms faced each other. Water, discharging from the two turbines, swirled together as it poured into the tailrace interfering with the efficiency of both turbines.[95]

Curiously, while Dayton Globe built some of the country's best turbines they were one of the last to solve this problem. An illustration printed by Gilbert, from a Dayton Globe catalog of the period shows the turbines which were installed in the Shenandoah Pulp Mill. They were housed in the boxlike housing that created so much interference for discharging water.[96]

The pulp mill soon remedied the problem. An early engineers's drawing of its turbine setting reveals that modern, camel-back cast iron draft chests had been installed to replace the boxlike housings.[97] The camel-back housing curved downward as it came off the back of each turbine creating downward channel for the discharging water. This downward flow was further encouraged by a partition inside the housing between the two turbine bottoms.[98]

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93 Safford and Hamilton, 1261.

94 Hunter, 380-383; Safford and Hamilton, 1281.

95 Safford and Hamilton, 1283.

96 Gilbert, 76.

97 T. H. Savery Papers (oversized materials).

A large draft tube that extended down into the tail race was another feature of the Improved New American and the Improved Success wheels. This innovation had made the vertically mounted turbine with horizontal shaft practical. Mounted to a draft tube, which resembled a cone with its top cut off, turbines could be raised above the surface of the tail race. Otherwise, equipment mounted horizontally to turbines submerged in the tailrace would, in turn, have to operate below the surface of the tail race. Now that they could function over the tail race, large rooms could be built around the turbines and any form of direct drive equipment installed.[99]

The Mill and the Community

The Shenandoah Pulp Company enjoyed an extended period of good sales. In 1908 it had more orders than it could fill. As late as 1924 demand for its pulp was very good. While trade papers that year reported the average sales price for a ton of pulp at $29 to $30, the company had managed to sell 100 tons at $33. One of its largest customers was Scott Paper Company."[100]

The mill employed as many as 51 employees who, in 1912, earned from $1.25 to $2.75 per day. The largest monthly paycheck in January of that year was earned by George Buzzard who took home $78.40 for 28-1/2 days work. Buzzard's check was larger than average, however. Most employees earned $1.50 a day for an average of around $30 to $40 per month. The payroll report that contains these figures also shows that the mill employed several members of the same families. Besides two Buzzards, the names of four Lougerbeams, three Benjamins and two Shoemakers appear.[101]

For the most part, the company enjoyed harmonious community relations. Lake Quigley supplied Harpers Ferry's water. When it froze in winter, the lake lured crowds of ice skaters and sleders. The mill generated electricity which lit the homes and streets of Harpers Ferry and surrounding communities. But conflicts arose.

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98 Safford and Hamilton, 1283-1284.

99 Hunter, 381-383; Frizell 307-309.

100 General Manager's Report,"Treasurer's Report."

101 Shenandoah Pulp Company, Monthly Payroll, January, 1912, Savery Collection.

In 1904, members of the Blue Ridge Rod and Gun Club accused the Savery mill and its sister mill on the Potomac side of Harpers Ferry of polluting the two rivers. Club members claimed that the wood shavings discharged by the mills "were backing up in cracks and pot holes in the river beds, killing fish and creating a terrible odor." The club brought together an influential group of environmentalists, including the Game Wardens of the States of Maryland, West Virginia and the District of Columbia to discuss the issue.[102]

Local newspapers carried stories of the controversy for several days. George Bready, a pulp mill executive, began a letter writing campaign attacking the gun club. He defended the Savery mill's value to the community stressing that it "supported 64 men and their families." He claimed that the wood shavings were harmless. Even though many of the gun club members were his personal friends, he suggested that their fishing problems were more readily explained by the effete spectacle of a nicker-clad gentleman sporting expensive tackle and little skill than by the mill's wood shavings.[103]

While apparently no legal action was taken to stop the dumping, the company attempted to rectify the problem. A letter, written by Bready to Thomas Savery's son, William, in March, 1905, refers to William's recommendation that the shavings be saved and sold as fuel for steam boilers. Bready told William that a local brewery had tried the shavings and found that they burned well. The magnitude of the pollution problem was revealed by Bready's remark that a ten hour run at the mill produced one hundred wagon loads of shavings. The brewery could burn no more than five or six wagon loads a day. Whether the problem was ever solved is not known.[104]

From Pulp Making to Electrical Generation

Ironically, horizontal shafting, which was such a boon to the mechanical pulp industry, foreshadowed the demise of the era of direct drive turbines. Like mechanical pulp wood grinders, electrical generators could also be mounted to a horizontal shaft.[105] It was quite simple, as the pulp mill later demonstrated, to simply remove a mechanical pulp grinder and install a generator in its place.

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102 Cumberland Evening News, 23 April 1904: 1.

103 George R. Bready, letter to John W. Avirett, 23 Aug. 1904, T. H. Savery Papers.

104 George R. Bready, letter to William H. Savery, 9 March, 1905, Pusey and Jones Company, Records, Hagley Museum, Wilmington, Delaware.

105 Hunter, 383-385.

Electricity offered many advantages over the direct drive turbine. It could be used to power electric motors which could drive a mill's equipment more efficiently. More importantly, however, excess electrical power could be sold. The excess power that a direct drive pulp mill's equipment could not use was lost. Used to generate electricity, this excess power could not only provide extra profit for a mill, it could also provide home lighting to surrounding communities.

Savery and his partners included in the Shenandoah Pulp Mill's charter the right to generate and sell electricity. The earliest date that they exercised this right is not known, but in 1904 the company leased one of its turbines to the Harpers Ferry Electric Light and Power Company for $600 a year.[106]

By 1924, one turbine that had formerly driven mill equipment was permanently mounted to a belt driven horizontal generator. The generator had a capacity of 150 kilovolt-amps and was equipped with its own switchboard. While the turbine remained under the technical ownership of the pulp mill, both it and the Harpers Ferry Electric Light and Power Company were owned by the same people;
the owners of the Harpers Ferry Paper Company. The president of the latter company was Thomas Savery's son, William.[107]

Since the pulp mill was part of an electric company, it survived longer than it probably would have from the profits of pulp manufacture alone. It's aging equipment, state of the art at the time it was installed, had become inefficient and obsolete by 1919. Replacement would have been unwise because the era of mechanical pulp mills was giving way. Larger mills integrating pulp and paper making into a single operation under one roof were now the norm.

The mill operated until the early thirties. While it continued to produce wood pulp, its major contribution to the community was now as a power generating plant of the Harpers Ferry Electric Light and Power Company. The history of this pioneering privately owned electric company, that provided the first electric lighting to the residents of Harpers Ferry surrounding communities, remains to be told.

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106 "Report and Appraisal, Harpers Ferry Electric Light and Power Company," Jan. 1928, p. 3, Savery Collection.

107 "Report and Appraisal." The information regarding the ownership of the three companies is contained in page one of a cover letter accompanying the report, information on the generator in the paper mill appears on pages 17 and 18, Savery Collection.

Flooding

Flooding often hastened the inevitable closing of water powered mills that had lost their profitability. The floods of 1924 and 1936 took such a toll of the Savery mill. In May 1924, production dropped to only 85 tons after rapidly rising waters forced the mill to temporarily shut down.[108] The flood washed away a portion of the stone retaining wall of Lake Quigley. Three hundred feet of railroad siding were washed out. One hundred railroad cars of cinder were required to refill the washout and 140 barrels of cement were required to repair damage to the retaining wall. Logs that had been soaking in Lake Quigley were washed away costing over $300 for recovery.[109]

The most lasting damage, however, was done to Virginius Island, the community. During the flood, all but two of the island's tenement houses had been vacated. They were never reoccupied. After nearly one hundred years, the era of Virginius Island as a community was at an end. On that momentous occasion, the only
good thing that happened was that waters of the Shenandoah had deposited several railroad cars of clean white sand. The company collected it to be sold to reimburse some of its financial loses.[110]

The flood of 1936 closed the story of Virginius Island. The pulp mill turned power generating plant had shut down the year before. Flood damage assured that it would never open again. All the old mills of the industrial village had long since been closed and their remains were mostly gone, washed away by one flood or another.

CONCLUSION

The one hundred year plus life cycle of Virginius Island provides a glimpse into American social and technological history. It is a complex picture set against a dynamic backdrop. As the story of the island unfolded, the United States was first attempting to settle its frontiers, then establish the ground work for industrial revolution. In the wilderness heavy, expensive steam

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108 "Shenandoah Pulp Company, General Manager's Report," 6 June, 1924, Savery Collection, Hagley Museum, Wilmington, Delaware, Joseph Wallace report, 2.

109 "General Manager's Report," "Shenandoah Pulp Company, Treasurer's Report," 16 July, 1924, Savery Collection, Hagley Museum, Wilmington, Delaware.

110 "General Manager's Report."

engines were not practical. Pioneering entrepreneurs turned to the centuries old technology of water power. Clusters of water powered mills and small communities grew up together. The more successful gradually turned their efforts from supplying local needs to participating in growing regional economies. A distinctly American prototype; the waterpowered industrial village, was born.

Even as they were being born however, the inevitable demise of these small manufacturing communities was foreordained. Steam power, and large cities were irresistibly on the rise. For a short time, from around the close of the eighteenth century until the latter part of the nineteenth century, rural industrial villages played a vital formative role. They steadily increased the growing nation's manufacturing capacity. They even symbolized a pastoral republican ideal, so dear to many early American thinkers, because they fit with such harmony into the natural landscape.

During the era of the industrial village some of the most profound transformations in the history of water wheels took place. After centuries of reliable service, tub, undershot and overshot wheels were replaced, within a few decades, by a succession of powerful, efficient turbine wheels. During the brief epoch when water turbines supplied the majority of the country's direct drive power, Virginius Island was in its prime. Because its entrepreneurs were always ready to adopt the latest technology, its history includes glimpses of at least three important stages in turbine evolution.

It would be a mistake to say the history of Virginius Island was an example of industrial failure. There were, as in the case of the cotton mills, some individual ventures that failed, but other mills operated for twenty, thirty, even fifty years. Instead, Virginius Island should be thought of as a prototypical American water powered industrial village. From this perspective, it is possible to visualize the life cycle of a community, a social organism, that lived and died by the technology and the economic imperative of its time.